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# Survey of Mango Postharvest Disease and Loss in the Western Parts of Ethiopia

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## Abstract

The survey was conducted from 2018 to 2019 with the aim of isolation and identifying important post-harvest diseases of mango fruits and estimating postharvest losses due to associated diseases. The physical loss measurements were made during harvesting, packaging, transporting and storage. Questioners were prepared to collect postharvest loss data on important factors of postharvest losses during storage or handling. The collected data was organized into graphs, charts and figures using statistical software using SPSS (version 26.0), excel and the difference between mean percentage incidence and frequency was separated by the Least Significant Difference (LSD). The survey results indicated that mango white scales are one of the most important insect pests that affect mango and it causes a loss of 69% by damaging the leaves and fruit. Similarly, there are physical losses: 7.5% due to mechanical damage/bruising, 15% if lately harvested, 2.5% from poor packaging, 1.5% from lack of good transportation, 13.5% from poor storage methods, 10% from market losses and 75% from *Colletotrichum* (anthracnose) disease, respectively. A high mean percentage of incidence and frequency of 85.33% and 55.44% of *Colletotrichum* species were observed in the samples collected from West Wollega. This was because of high humidity, rainfall, and high natural forest in the area, which created a conducive environment for the development of the disease and inoculum from the previous. From this study, it was concluded that although many studies are done on the management of mango white scales, there is still a bottleneck in the production and productivity of mango fruits in the area through anthracnose disease transmission. Most of the people in the surveyed areas used the diseased mango fruits for consumption, which causes health problems and this requires further study on the health effects of the diseases.

**Keywords:** Storage fungi; Post harvest loss; Disease incidence; *Mangifera indica*; Perishable crops

## Introduction

Fruit production plays a major role in the local economy as a means of earning livelihoods for nearly five million farmers, creating jobs and generating foreign exchange revenues in Ethiopia. Consequently, the Ethiopian government in its second Growth and Transformation Plan (GTP) that covers 2015-2020 provided a greater emphasis on increasing the production of fruit crops by nearly 50% from the existing NPC (National Planning Commission 2016). Mango is the second most important fruit crop next to banana in Ethiopia. It covered about 19,497.92 hectares (ha). Out of 119,908.57 ha, the total area covered by fruit is 16.21%. A total of 1,337,049.26 quintals of mango was produced in the 2018/19 production season with a productivity level of 68.57 quintals per ha [1]. Among the regions of Ethiopia, Harari, West and East Oromia, Southern Nations, Nationalities and People's Region (SNNPR) and Amhara are the main mangoes producing regions. The perishability of the fruit is attributed to rapid deterioration after harvest [2]. It is also susceptible to insect pest infestation and decay causing postharvest losses due to a lack of proper pre-harvest practices. Mango has a short shelf life and is vulnerable to environmental stress, especially high temperatures. Considerable quantities of mangoes are lost every year during harvesting, transport and marketing. Losses of fresh mango fruits are reported to be 25%-40% in India and 69% in Pakistan and microbial decay accounts for 17.0%-26.9% of the total post-harvest losses in Asian countries [3]. Lohani, et al., indicated that softening caused by enzymatic degradation of carbohydrates and cell wall components is among the principal contributors to postharvest losses in fresh mango fruits. Many studies were done with regard to mango value chain constraints and post-harvest loss assessment in Ethiopia. The research done on the post-harvest mango disease and losses was not as sufficient [4].

This lack of information prevents the export of quality mango fruits as well as the supply of the diseased free mango fruits to factories and for local consumption, most people consume the diseased fruits, which causes health problems. Also, these prevent them from recognizing the socioeconomic, nutritional and environmental significance of the post-harvest loss problem. Unlike the previous studies, this study relied on the assessment of harvest and post-harvest handling practices of farmers, retailers and wholesalers and loss along the mango value chain due to post-harvest disease [5].

Improving the post-harvesting handling practice not only increases production by reducing post-harvest loss but also increases shelf life and helps the price adjustment at the market level [6]. In addition, reducing post-harvest losses instead of increasing food production not only makes food available to consumers but also saves scarce resources and reduces environmental pollution due to intensive farming. Thus, this study result has multiple effects both on the

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production and the consumption side. By doing so, this study contributes to evolving literature on the post-harvest improvement of mango value chains. Due to the importance of mango as an agricultural product and the lack of knowledge about how to reduce its post-harvest diseases and losses, this research study was carried out to fill this gap. However, the majority of the research has focused on pre-harvest diseases and losses and the adaption of improved varieties. While most of these studies offer useful insights into identifying production potentials and constraints, marketing supply channels and potential factors influencing value chain participation, they are limited in many ways [7]. Still, postharvest diseases and losses of mango at the grower, collector, transport, wholesaler and retailer levels are not clearly understood. Correspondingly, the technologies such as processing, handling, transportation and storage of mango in Ethiopia are not known, which results in the short shelf life of this commodity. Therefore, the objectives of this study were to isolate and identify important diseases in mango and to estimate postharvest losses due to associated postharvest diseases [8].

## Materials and Methods

### Description of the study area

The samples were collected from Asosa, West and East Wollega and West Shewa (Bako and Ilugellan) areas. During the survey, a total of 14 woredas and 107 mango producing farmers were assessed. In those areas, there were also avocado, orange, papaya, lemon, guava and other fruits produced in those areas, but mango is the major fruit in the Western parts (Figure 1).

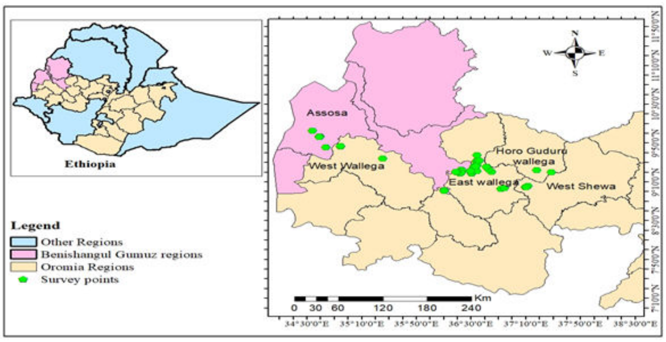


**Figure 1:** Major mango survey areas in the Western parts of Ethiopia.

### Sampling methods and sample size

Physical damage, diseased and unmarketable mango fruits were collected from major producing woredas and kebeles in the western parts of Ethiopia and direct loss was measured through visual observation and laboratory identification. The physical loss measurements were made during harvesting, packaging, transporting and storage. Ten active farmers, retailers and wholesalers were selected for interviews and a loss was estimated. Questioners were prepared to collect postharvest loss data on important factors of postharvest losses during storage or handling. Different storage/package types and methods were assessed [9]. Loss due to mechanical damage and/or bruising and associated diseases was identified. The contaminated mango fruits that give unpleasant odors were added to the loss because they are unfit for human consumption. Finally, the mango producers' farmers were selected by a simple random sampling technique based on the probability proportional following the formula given by Yamane.

$$n = \frac{N}{1 + N\,(e^2)}$$

Where,

N=Sample size.

N=Total number of households.

e=Desired level of precision, which was taken to be 9%.

### Isolation and identification fungal species

**Agar plate method:** Mango fruit samples were collected to detect associated diseases from the samples taken from fields and retailers' storage. Diseased mango fruits with and without surface disinfection were used and the cuts were aseptically placed on Potato Dextrose Agar (PDA) using the method of agar plate according to the standard procedures. The laboratory analysis was carried out in the ambo plant protection research center mycology laboratory department. Each molded, rotted and decayed fruit sample was used for diagnosis in the labs. Associated fungal and bacterial diseases were grown using their respective media and identified through the use of a microscope. Initially, the freshly harvested fruits were used and periodically the stored mango fruits were used and thoroughly washed with distilled water during each period. From surface disinfected and non-disinfected samples, three pieces of cuts/petridish/plate (9 cm diameter plates) containing Potato Dextrose Agar (PDA) were aseptically placed with three replications [10]. The plate that contains the fungus was incubated at 26°C for 7 days and after 7 days of incubation, the identification of fungus isolates was done based on: Septate, growth rate, color and morphology of mycelia, conidia and sporulation structures. Then, the isolated fungi were subcultured after three days of incubation for purification of the isolate. Finally, the incidence of isolation of fungi (%) and frequency of isolation of fungi (%) were calculated as follows:

$$\text{Incidence (\%)} = \frac{\text{Number of diseased mango fruits}}{\text{Total number of mango fruits sampled}} \times 100$$

**Isolation Frequency (IF):** For each fungus, the proportion of samples that yielded its isolates were determined and expressed as percent by using the following formula:

$$\text{Frequency (\%)} = \frac{\text{Number of occurance of disease in the samples}}{\text{Total number of samples}} \times 100$$

**Data analysis:** The collected data was organized into graphs, charts and tables and analyzed using descriptive statistics using SPSS version 26.0 statistical software. Appropriate statistical methods such as frequency, average and percentage were used. The percentage of post-harvest losses and quality deterioration in different post-harvest areas was measured using the modified equation suggested by Debele, et al.

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## Results and Discussion

### Factors for post loss of mango fruits in the study areas

**Insect pests and diseases:** Mango white scales are one of the major problems of mango that affect all parts of the plant in the surveyed areas and they cause a loss of up to 50%-88% by damaging the leaves and fruit. According to Figure 2, these insect pests not only destroy the leaves of the plants but also feed the fruits and create favorable conditions for disease development. Other losses are: Losses caused by apes, monkeys, and thieves accounted for up to 25% and these losses reached up to 10%-20% when the fruits were not picked earlier or lately harvested [11]. In visual observation, several postharvest diseases of mango fruits were recorded, like fruit rot, bacterial speck, phoma blight, bacteria canker, sooty mould and malformations are the major. Among these, losses caused by *Colletotrichum* (anthracnose) reached up to 30%-90%. The recent study by Souza-pollo and de Goes showed that if there were suitable conditions for disease development, the losses reached up to 100%. Msogoya and Kimaro indicated that 48%-60% losses of fresh mango were recorded in Tanzania due to this disease.


**Figure 2:** Visual score of mango anthracnose disease in market.

**Environmental factors:** Several factors caused postharvest losses of mango fruit in the study areas. Among these, environmental factors such as temperature, relative humidity, rainfall and natural forests are the major ones that make it a conducive condition for disease development and thus reduce the shelf life of the fruits after harvest. From this study, the interviewed farmers interpreted a loss of 1 sacks-2 sacks of the fruit that were rotted out of 10 sacks because of these factors and missing handling practices [12].

**Harvesting/picking losses:** During the assessment, it was observed that losses at picking/harvesting reached 5%-10% because of mechanical damage/bruising by long sticks hooking the fruits to the ground, shaking the trees and falling to the ground, biting, and biting the sticks and these create favorable conditions for disease development. Thus, Theodosy et al. explained that the highest postharvest losses of 30.6 % were recorded in the wholesale market, followed by the transport and harvest losses of 10.6% and 2.6%, respectively (Figure 3).

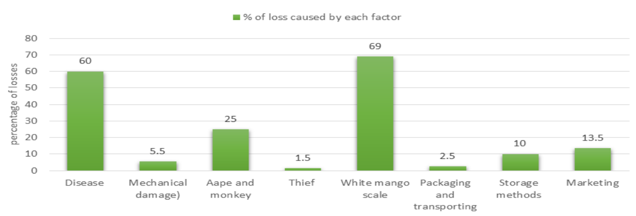


**Figure 3:** The bar graph displays the factors of post-harvest mango fruits.

**Packaging and transportation losses:** There is no good packaging equipment and the farmers use baskets or sacks and cartons for the packaging materials. As observed, the losses at the packaging and transportation stages reached up to 2.5% and the losses reached more when the fruits have fully ripened. Also Figure 4 displays Uke mango green farms, which were handled by Indian people, were the best methods of packaging materials that reduced the packaging and transportation losses but also contaminated with soil as they keep the basket in bare soil. This farm distributes the fruits to local cafeterias and juice industries, for wholesalers and also exports them to their countries [13].

**Figure 4:** Mango packaging at Uke green farms.

**Storage and market losses:** There are mango fruits losses at the storage and markets. 5%-15% of losses were observed during storage due to a lack of good storage facilities and farmers, retailers and wholesalers absence of a cold room [14]. In other ways, 10%-16% of losses were recorded at the market because the farmers did not use the shade in the marketing and then they sold in the sun which favors the fruits to rot within a short time. This increased the deterioration of the fruits by increasing the ethylene content of the fruits and reducing the shelf life [15]. So, most of the mango sellers lost several quintals at a time which reduces the sales price. Few retailers keep their fruits on the shelf and this helps to keep the fruit's shelf life. In another case, Spadaro, et al., indicated a contradiction from the present studies' results; at the wholesale level, there was a maximum loss of 30.6% that was observed at this stage (Figure 5).

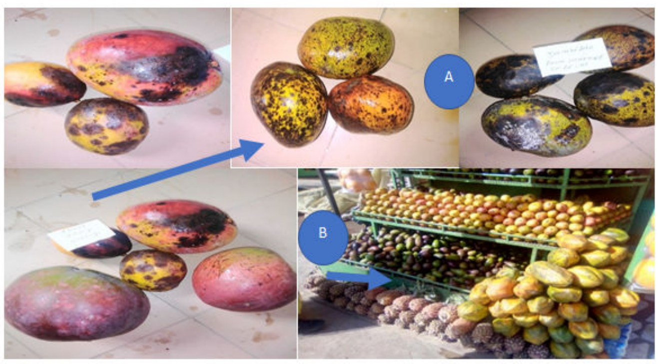


**Figure 5:** Observation of mango fruits markets: A=Farmers sell, B=Retailers sell.

**Incidence and frequency percentage of fungus species identified from mango fruits:** Figure 6 shows the mean percentage incidence of fungus species identified from mango fruit samples. Five fungi genera; *Colletotrichum* (Anthracnose), *Aspergillus*, *Fusarium*, *Alternaria* and *Trichoderma* spp. were identified from the collected samples. A high mean percentage incidence of 85.33% of *Colletotrichum* species (anthracnose) was obtained in the samples collected from West Wollega, whereas a low mean of 49.57% was found in the samples of West Shewa [16]. *Fusarium* fruit rot was the second most important fungus that was identified from the samples with a high mean of 55.60% in the West Shewa and a low mean of 14.00% in samples of East Wollega. While Gadgile and Chavan identified *Aspergillus niger*, anthracnose and *Rhizopus* rot in infected postharvest mango fruit [17].

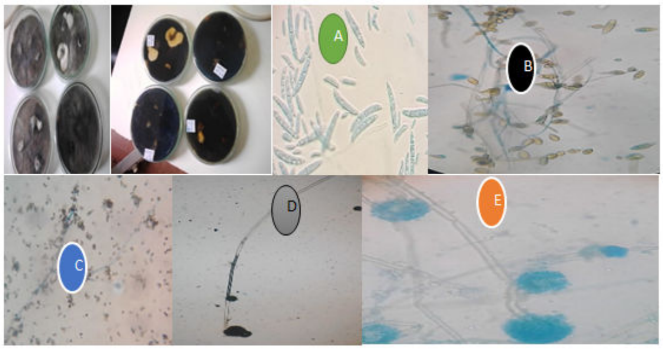


**Figure 6:** Fungal species identified: A) *Fusarium* spp., B) *Alternaria* spp., C) *Colletotrichum* spp., D and E) *Aspergillus* spp.

However, Okereke, et al., identified fungi species *A. niger*, *Alternaria* spp., *B. theobromae* and *C. gloeosporioides*. The study results showed that the incidence of anthracnose was found to be 41%-72.1% on leaves and 36.2%-76% on mango fruit, while it was recorded 80%-100% incidence on leaves, 40%-90% on fruits in the present study. The major causes of mango fruit losses are postharvest diseases, including fruit rot (stem end rot) disease caused by *Lasiodiplodia theobromae* and anthracnose caused by *Colletotrichum gloeosporioides* [18]. Anthracnose found in the present results ranged between 3.33%-63.33%, while according to the results, anthracnose falls between 5%-60%. The disease incidence was as high as 32% in South Africa and 64.6% in Costa Rica in 1990. According to Arauz, the incidence can reach almost 100% in fruit produced under wet or very humid conditions. Anthracnose causes 30%-60% yield losses on mango across different countries of the world (Figure 7).

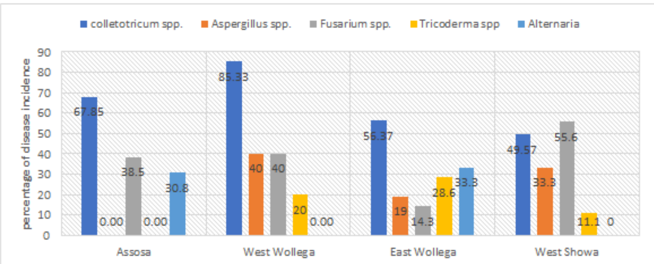


**Figure 7:** Mean percentage of incidence of fungal species identified from the mango fruits.

There was a significant difference ($p<0.05$) of the mean percentage frequency of fungal species (Figure 8). A high mean of 47.88% and 45.66% of the frequency of *Colletotrichum* spp. was observed in the samples of West Shewa and Asosa areas, respectively. Similarly, *Aspergillus* spp. frequently occurred with a high mean of 40.00% in the samples collected from West Wollega areas [19]. This was because of high humidity, rainfall and high natural forest for the development of the disease. *Aspergillus* rot incidence was found to be 3.33%-53.3%, a severity range of 1-5 and a percent disease index of 22%-48% in the present study, while, according to Meer, et al., their study areas had disease incidence of *Aspergillus* rot range from 0%-16.66%, severity range of 1-5 and percent disease index of 0-3.33. Anthracnose, stem end rot and *Aspergillus* rot are more prevalent in moist conditions and high humidity [20]. In areas with heavy rainfall during flowering and fruit set, anthracnose is more prevalent, leading to serious losses of up to 35% of fruits. Suitable environmental conditions for the attack of blossom blight include cool weather, heavy dew and fog. Twig blight has an optimum temperature range of 20°C-30°C for the growth of *Lasiodiplodia theobromae*.

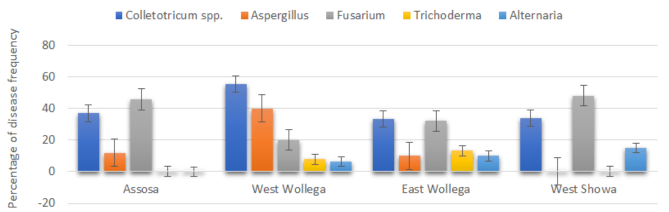


**Figure 8:** The graph shows the assessment of mango fruits postharvest loss.

## Conclusion

The study indicated that mango white scales are one of the major insect pests that attack the leaves and fruits in all the surveyed areas and it causes a total yield loss by damaging plant parts. A large percentage of the fruit was rotted at the retailers and wholesalers because of a lack of cold room storage and improper handling practices. The results indicated that five fungi genera; *Colletotrichum* (Anthracnose), *Aspergillus*, *Fusarium*, *Alternaria* and *Trichoderma* spp. were identified from the samples collected. The mean percentage incidence of *Colletotrichum* species (Anthracnose) was high in the assessment areas, except in the West Shewa where a low mean was observed. *Fusarium* fruit rot of mango was the second most important fungus that occurred with a high mean percentage incidence in the samples obtained from West Shewa. Generally, high postharvest losses of mango fruits were recorded during harvesting and marketing because of mechanical damage, lack of improper packaging materials and inaccessibility to the cold room. In the Western parts of Ethiopia, there is heavy rainfall and forest which creates a conducive environment for the prevalence and incidence of *Colletotrichum* diseases during flowering and in fruit settings and it is more prevalent when the fruits are fully matured and also after harvest. Most of the people in the surveyed areas used the diseased mango fruits for consumption freshly and in juice making at cafe, which causes health problems and this requires further study on the health effects of the diseases.

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## Conflict of Interest

The authors have not declared any conflict of interests regarding the materials.

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## Authors' Declaration

**Negasa Fufa:** Data gathering and analysis, project initiation, writing original draft.

**Tekalign Zeleke:** Supervision, validation, review and editing.

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